

# Post-Detection Subcarrier Recording Equipment Implementation for Analog Recording Playback

G. Hamilton

DSIF Digital Systems Development Section

*The post-detection subcarrier recording reproduce capability has been implemented at the playback facility for playback of analog tapes recorded at stations in the DSIF. The primary purpose for this facility is to reproduce the analog tape data (which could not be played back at the stations) if a failure in the station subcarrier demodulator assembly or on the spacecraft occurs. The analog data is used to produce digital data tapes and to generate data for input to the SFOF. Reproduce modes of baseband playback and telemetry data bit stream playback are discussed.*

## I. Introduction

The DSIF post-detection subcarrier recording playback capability has been implemented at the playback facility for playback of analog tapes recorded at stations in the DSIF.

The post-detection subcarrier recording (PDSR) equipment was required in order to provide a back-up capability for retrieval of telemetry data which may otherwise be lost due to spacecraft or ground equipment malfunction. The implementation provided a high-performance

(low flutter/time base error) playback capability for recovery of data not possible with the analog recording equipment previously available.

Existing recording equipment was not suitable for accurately reproducing the higher data rates required for *Mariner 71*, *Mariner Venus-Mercury 73*, and *Viking 75*. Further, severe time base stability constraints were imposed on the analog recording equipment by other station equipment with which it was to operate. This required that phase stability of the recovered signal must be

maintained for processing uncoded, block-coded, and convolutional-coded data with narrow-band detection equipment of the telemetry processing stream.

## II. Equipment Selection

The evaluation of equipment suitable for meeting these requirements resulted in the selection and subsequent procurement of two FR-2000 magnetic tape transports and electronics, manufactured by the Ampex Corporation. The evaluation established that time-base stability of the reproduce equipment was the critical parameter controlling the record/reproduce process. This indicated that existing recording equipment, specifically the FR 1400 recorders presently available at the sites, were adequate, providing that playback was performed on a tape transport with low time displacement error (TDE).

As such, the two Ampex Model FR 2000 transports were selected and installed at the playback facility in CTA 21 to perform the post-detection subcarrier record/reproduce function. The FR 2000 was selected primarily because of its low TDE to which the subcarrier demodulator assembly (SDA) is particularly sensitive. The peak-to-peak time displacement error is of the order of  $0.25 \mu\text{s}$ , which may be compared with a TDE of  $250 \mu\text{s}$  for the FR 1400. Also installed in one FR 2000 cabinet is a bank of discriminators used either: (1) to recover time, data, receiver AGC, and receiver static phase error from the recorded station parameters multiplexed on tape, or (2) to extract the SDA output (bit stream) previously recorded.

## III. Playback Modes

The post-detection record/reproduce capability has been performed successfully for: (1) baseband (telemetry subcarrier) playback (Ref. 2) directly into the up converter of the SDA; (2) telemetry data bit-stream playback into the TCP; and (3) science data playback into the SSA.

## IV. Baseband Playback

One of the primary reasons for the implementation of the post-detection recording at CTA 21 is to provide a means for the playback of baseband telemetry subcarrier data in the event of a spacecraft or SDA malfunction, such that the SDA would be unable to lock on to the signal in real-time. Baseband playback has been demonstrated down to a recorded level of  $4\text{-dB } ST_B/N_0$ . Tapes have been played back from CTA 21 to the SFOF, and the

digital tapes produced satisfactorily. The playback of baseband, however, is accompanied by a degradation relatively independent of the SNR of the recorded signal. This degradation is approximately 2 dB, worsening slightly if high science rate is recorded at less than 152 cm/s (60 in./s). Time base error is one source of this degradation.

It has also been found necessary to introduce sufficient gain into the baseband coded data stream playback to compensate for signal suppression incurred in the receiver output amplifier during the recording process. This gain is a function of both data rate and expected SNR. The gain required is dependent on a particular setting of the mod index attenuator at the SDA. However, it should not be inferred that the mod index may be used without the external gain to compensate for signal suppression, because the mod index control and the external gain affect the signal at different points in the circuit.

## V. Telemetry Bit Stream Playback

Telemetry bit stream playback has been successfully performed both at CTA 21 and at the stations for about a year. This playback is accomplished by using either the FR 1400 or the FR 2000 transports. The procedure involves applying the output of the proper track on the tape to a discriminator. The discriminator used is dependent upon: (1) whether the bit stream is engineering or science data and (2) whether it was recorded at a 26-m or at a 64-m station. The demodulated data stream is then applied to either the telemetry and command processor (TCP) or the symbol synchronizer assembly (SSA), for engineering or science data respectively. The TCP then controls the processing of data. Playback of strong signals ( $18 \text{ dB } ST_B/N_0$ ) is accompanied by a degradation of approximately 4 dB. Signals recorded at 7 dB are degraded by 0.5 dB. Degradation falls to a minimum of about 0.2 dB at a recorded signal level of 4.5 dB or below. The limit of bit stream playback capability is presently about  $4.5 \text{ dB } ST_B/N_0$ . Below this level, the SSA begins to lose lock or lock becomes intermittent.

## VI. Comparison of Baseband and Telemetry Bit Stream Playback Modes

Some comparison of the two methods of data playback of the baseband and the telemetry bit stream may be in order at this point. Given the recorder and reproducer in optimum condition, it would seem that for signals stronger than  $10 \text{ dB } ST_B/N_0$ , baseband playback would result in less degradation. For signals below  $10 \text{ dB } ST_B/N_0$ , less

degradation occurs using telemetry bit stream playback. The complexity of setup is about the same in either case. The baseband requires the setup of external gain, while the bit stream requires precise zeroing of the playback discriminators.

## VII. Additional Requirements

When playing back baseband to the SFOF or when making a digital tape, it is a requirement that the 1 pps required for TCP operation and the time of day of the occurrence of data be derived from the analog data tape. This is accomplished by feeding the previously recorded

NASA 36-bit time code translator (TCT). The TCT then derives the 1 pps and BCD time code. A switching unit then is used to transfer the time input to the TCP from its regular source (the FTS) to the playback source (tape).

## VIII. Command Demodulation

A convenient method of demodulating the recorded command signal was devised (Ref. 1). It consists of demodulating the command signal from the multiplex using a tunable discriminator with an output filter bandpass of 250 Hz. The signal is then fed to the SDA for data extraction.

## References

1. *DSIF Standard Test Procedure No. 853-27/2A-03*, Telemetry and Command System Analog Recording and Playback Procedure (JPL internal document), Dec. 1, 1971.
2. Johnson, D., and Meeks, W., *Analog Baseband Playback Procedure*, IOM 337E-71-149 (JPL internal document), Nov. 10, 1971.